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The Effect of a Monocular Helmet-Mounted Display on Aircrew Health: A Cohort Study of Apache AH MK1 Pilots Initial Report

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A collaborative occupational health study has been undertaken by Headquarters Director Army Aviation, Middle Wallop, UK, and the U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, to determine if the use of the monocular helmet-mounted display in the Apache AH Mk1 attack helicopter has any long-term (10-year) effect on visual performance. This paper describes the protocol, methodology, development and initial execution phase of this study. The test methodology consists primarily of a battery of vision tests selected to capture changes in visual performance (with an emphasis on binocular visual functions) of Apache aviators over their flight career. Additional sections address demographics, contact lens use, and handedness. It is anticipated that the number of Apache aviators will level out to approximately 70 by the end of the first 3 years of the study. Non-Apache aviators will serve as a control group.

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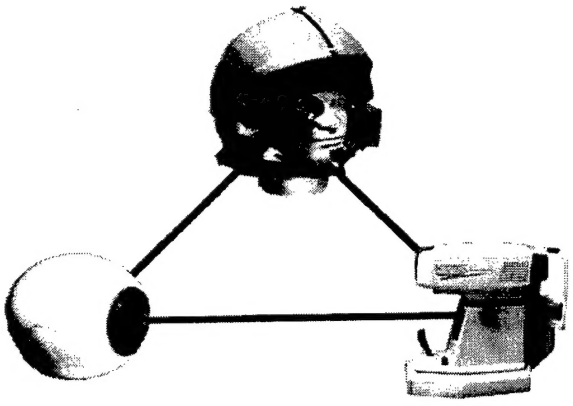
Preface

This is the first in a series of technical reports describing the study titled *The Effect of a Monocular Helmet-Mounted Display on Aircrew Health: A Cohort Study of Apache AH Mk 1 Pilots*. The principal aim of this occupational health study is to determine if the use of the monocular helmet-mounted display (HMD) in the British Army's Apache AH Mk 1 attack helicopter has any long-term effect on visual performance. Additional information concerning other unique problems of the Apache AH Mk 1 aircrew is elicited as a secondary objective. This study is a collaborative effort between the British Army and the U.S. Army, and is conducted under the auspices of The Technical Cooperative Program, Subgroup U, Technical Panel 7, (Human Factors in the Aviation Environment). This initial report describes the study's protocol, methodology, development and initial execution phase in detail. Future interim reports will be published on a biennial basis, which will discuss progress made over the preceding years and provide any identified data trends. A final technical report will be published in approximately 10 years time (~2010) and will review all data gathered, provide statistical analysis thereof, and develop conclusions regarding the study questions.



The Apache AH Mk 1 cohort study logo.

Acknowledgments

This work was supported by the United States Army Aeromedical Research Laboratory, Fort Rucker, Alabama; the Ministry of Defence - British Army Air Corps, UK; and the Drummond Trust Foundation, administered by the Military Assistant To The Director General Army Medical Services. Army Medical Directorate, Keogh Barracks. Aldershot, Hampshire, UK.

The ambitious scope of this study has necessitated a large effort by a great number of individuals over an extended time period. The role and contributions of the major contributors are as follows (in alphabetical order):

- COL Malcolm G. Braithwaite, OBE, L/RAMC, Consultant Advisor in Aviation Medicine, Headquarters Director Army Aviation, Middle Wallop, UK, participated in development of study protocol and currently serves as UK study leader.

- COL John S. Crowley, MD, MPH, U.S. Army Medical Corps, Director, Aircrew Protection Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, USA, participated in development of study protocol as former Aeromedical Exchange Officer to UK and currently serves as U.S. medical consultant to study.

- Lt Col (Retired) Allison J. Eke, RAMC, Consultant in Aviation Medicine, formerly at Defence Evaluation and Research Agency, Centre for Human Sciences, Farnborough, UK.

- LTC Keith L. Hiatt, MD, MPH, U.S. Army Medical Corps, Aerospace Medicine Consultant - Apache Systems, Headquarters Director Army Aviation, Middle Wallop, UK, is the Aeromedical Exchange Officer to UK and is the study's current principal investigator.

- LTC Corina Van de Pol, O.D. PhD, Director, Aircrew Health and Performance Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, USA, serves as U.S. vision consultant to study.

- Daniel J. Ranchino, BS, Computer Specialist, Research Support Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, USA, developed architecture for and maintains study database.

- Clarence E. Rash, BS, MS, Research Physicist, Aircrew Health and Performance Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, USA, developed visual test battery and serves as U.S. technical coordinator.

- LTC William K. Statz, DO, MPH, U.S. Army Medical Corps, Formerly at DERA Centre for Human Sciences, Farnborough, UK, participated in development of study protocol as former Aeromedical Exchange Officer to UK.

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Introduction

The British government has purchased 67 Apache AH Mk 1 attack helicopters (formerly identified as the WAH-64). The Apache AH Mk 1 is the latest version of the highly successful AH-64A "Apache" helicopter flown extensively by the U.S. Army, and it incorporates many significant improvements (Figure 1). Among these are a fire control radar, improved weapons processors, a glass cockpit, improved data modem, and a multitude of engineering enhancements to overall system architecture and components (Sale and Lund, 1993). This acquisition program is considered an "off-the-shelf" buy, and in many respects, the Apache AH Mk 1 is similar to the Apache Longbow AH-64D helicopter being acquired by the U.S. Army.

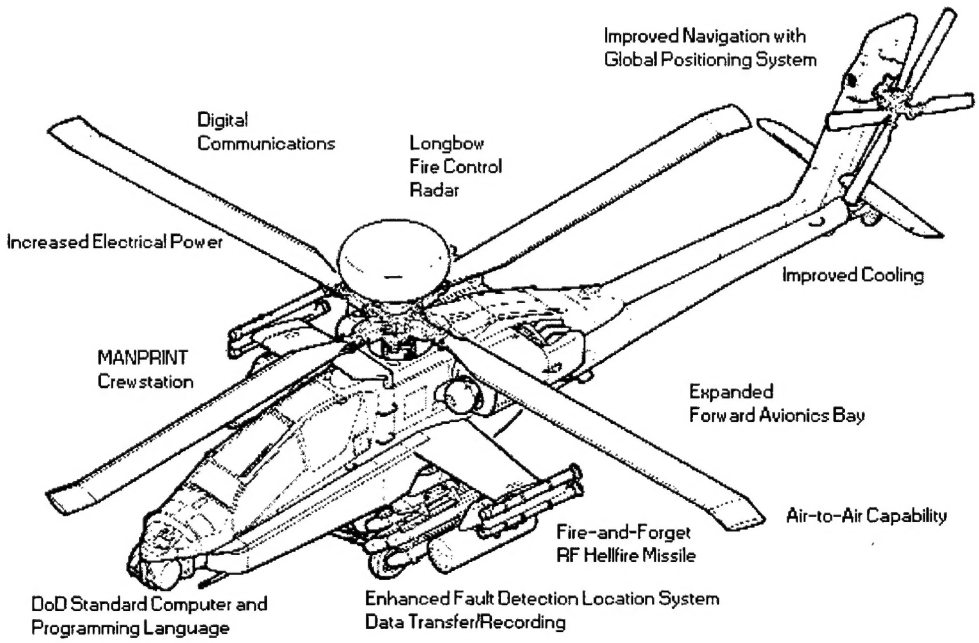

Figure 1. Features of the Westland Apache AH Mk 1, similar to the Boeing Longbow AH-64D (Sale and Lund, 1993).

The protective flight helmet used to date by AH-64A pilots is the Integrated Helmet and Display Sighting System (IHADSS) (Figure 2) (Rash and Martin, 1988). The IHADSS provides sensor video and/or symbology to each crewmember via a helmet display unit (HDU). The HDU contains a 1-inch cathode ray tube (CRT) attached to the right side of the helmet, positioning a combiner lens directly in front of the pilot's right eye. When in use, the HDU usually rests on the pilot's right maxilla/zygomatic arch (right cheekbone); when not needed, it can be rotated away from the face.

Figure 2. The AH-64 Integrated Helmet and Display Sighting System (IHADSS) (Rash and Martin, 1988).

At times, the Apache pilot's only source of visual information about the aircraft's state and the outside environment is the HDU. Compelling the aviator to rely on a degraded unnatural view of the world, which is provided only to the right eye, has been noted to cause psychological and physiological problems for many Apache pilots (Behar et al., 1990; Rash and Martin, 1988). Experience has shown that these problems can be generally overcome with training. However, there are residual long-term concerns that have not been completely studied--these will be reviewed later in this paper. Suffice it to say that, while user surveys frequently elicit worrisome symptoms, it has been virtually impossible to locate affected pilots for follow-up study. As long-term safety for use of the Apache AH Mk 1 helmet-mounted display (HMD) has yet to be established, there is a legitimate duty-of-care requirement to monitor those exposed.

No upgrade is presently planned for the basic IHADSS helmet and HDU for the Apache AH Mk 1 (or the U.S. Army Longbow Apache) (Crowley and Johnson, 1998). The lessons learned by the U.S. Army regarding the AH-64A will therefore be of great use to the British Army Air Corps, and a careful study of these residual HDU/IHADSS concerns in a newly exposed population (i.e. The British Army Air Corps Apache pilots) will be invaluable to both the British and U.S. Armies. It will be critically important, however, to ensure that pilots experiencing troublesome symptoms be retained in such a study.

The principal aim of this occupational health study is to determine if the use of the monocular helmet-mounted display (HMD) in the British Army's Apache AH Mk 1 attack helicopter has any long-term effect on visual performance. This initial report describes the study's protocol, methodology, development and initial execution phase in detail.

Background and review of the extant literature

After the initial fielding of the AH-64A, numerous anecdotal reports of various physical and psychological/sensory problems surfaced. User surveys documented increased rates of fatigue and other symptoms generally attributed to the IHADSS/HDU (Behar et al., 1990; Hale and Piccione, 1990; Crowley, 1991). Hale and Piccione (1990) conducted a user survey of instructor pilots at Fort Rucker, Alabama, and found evidence of increased aviator fatigue and, among other complaints, headaches. They cited as possible causes the following IHADSS-related factors: binocular rivalry, narrow field of view (FOV), poor depth perception, inadequate eye relief, and overall system discomfort. The possible relevance of other perceptual effects of HMDs, such as object "minification," also was explored.

To investigate potential medical concerns of long-term physiological effects of using the IHADSS, the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, Alabama, conducted a three-part study (Behar et al., 1990). The first part was a written questionnaire that documented specific visual problems experienced by the local Apache aviator community. The second part was a clinical and laboratory evaluation of the refractive and visual status of a sample of these aviators. The third part was an assessment of the diopter focus settings used by aviators in the field environment. Since the IHADSS is designed to have the virtual imagery appear at optical infinity, incorrect diopter focus settings could, in theory, lead to visual fatigue and related visual problems.

A total of 58 Apache aviator questionnaires were completed. More than 80 percent of the sample aviators reported at least one visual complaint associated with flying or after flying with the IHADSS. A summary of complaints is provided in Table 1 (Behar et al., 1990). The most common complaint (51 percent) was that of "visual discomfort" during flight. Approximately one third of the aviators reported occasional headaches, and about 20 percent reported blurred vision and/or disorientation *while* flying. The percentage of aviators reporting headache and blurred vision *after* flying remained about the same, while the percentage of those experiencing disorientation *after* flying decreased to five percent.

Table 1.
Apache aviator reports of visual complaints during and after flight. (Behar et al., 1990)
(Expressed in percent)

Complaint	During flight			After flight		
	Never	Sometimes	Always	Never	Sometimes	Always
Visual discomfort	49	51	--	70	28	2
Headache	65	35	--	67	32	2
Double vision	86	12	2	89	9	2
Blurred vision	79	21	--	72	24	3
Disorientation	81	19	--	95	5	--
After-images	NA	NA	NA	79	19	2

The clinical and laboratory evaluation of the refractive and visual status of 10 aviators found no statistical correlation between visual performance and visual complaints. There were no significant differences found between right and left eye performance. There was evidence of mild incipient presbyopia in a majority of the aviators, but this was within expectations for the sample age range. Binocular motility for the sample was found to be lower than expected. In summary, the study concluded there was no significant variation from normal performance values noted. However, an acknowledged shortcoming of this part of the study was that none of these 10 aviators voiced significant complaints or sequelae related to the IHADSS (i.e., the pilots complaining of visual problems apparently didn't volunteer for this part of the study).

The diopter focus settings of 20 Apache aviators (11 students and 9 instructor pilots) were measured in the aircraft following their normal preflight set-up. Nine were measured under nighttime illumination conditions and 10 under daytime conditions. A range of focus settings from 0 to -5.25 diopters (a mean of -2.28 diopters) was obtained. It was concluded that the required positive accommodation by the eye to offset these negative focus settings was a likely source of headaches and visual discomfort during and following long flights. No correlation was found between the focus settings and aviator age, or experience; nor were there differences between instructor pilots and students, or day versus night.

In another survey of 242 aviators flying either ANVIS night vision goggles (NVG) (rotary- and fixed wing), or IHADSS, a very small percentage of the 212 rotary-wing ANVIS users reported purely physiological effects, including eyestrain (three percent), headache (two percent), motion sickness/vomiting (two percent), postflight blurred vision (one percent), and dizziness (one percent). Only five percent of responding Apache aviators (n = 21) reported any visual problems (that of dark adaptation effects) (Crowley, 1991). However, numerous respondents described visual/perceptual problems with the various night vision systems used. The most common phenomena reported were illusions of aircraft drift while hovering.

Currently, HMDs designed for use in the Army aviation community are required to provide some measure of look-under, look-around, and/or look-through capability. However, future HMD designs may employ full-immersion displays in the form of virtual reality display systems. There is considerable ongoing effort to investigate a phenomenon known as "cybersickness" associated with such systems. Cybersickness is similar to simulator sickness in that symptoms of motion sickness (e.g., nausea, sweating, pallor, etc.) can result from a lack of correlation between visual and vestibular sensory inputs. Of course, in an actual aircraft, both inputs are present. However, if imagery has a significant delay in its presentation due to long lag times and slow update rates, cybersickness can manifest itself (Melzer and Moffitt, 1997; Kalawsky, 1993; Hettinger and Riccio, 1992). Even greater concerns have been voiced regarding possible damage to the vestibulo-ocular reflex due to HMD use, manifesting in flashback episodes (Melzer and Moffitt, 1997; Strauss, 1995). These symptoms are similar to those voiced by Apache pilots flying the monocular IHADSS system.

To summarize this brief review of visual problems associated with the AH-64A, there have been several well-documented user surveys echoing the same concerns: visual fatigue, ocular rivalry, eyestrain, etc. There is evidence that some of these problems can be alleviated with

proper training (Behar et al., 1990) and that most are less common with accumulated experience in the Apache aircraft (Crowley, 1991), but this has not been studied in a longitudinal fashion. Further, while the few laboratory studies of Apache aircrew have failed to demonstrate any significant changes in visual performance, the aviators included in those studies have not been symptomatic, i.e., the affected sub-population of interest has actually not been studied. A longitudinal cohort study of Apache pilots, to include both an annual subjective questionnaire as well as an objective, in depth vision exam is better suited to determine the true incidence rates and track the symptomatic individuals.

AH-64 pilots requiring visual correction have worn soft contact lenses (SCLs) for nearly a decade, and SCLs were used successfully in Operations Desert Shield and Storm (Lattimore and Cornum, 1992). A program to allow Apache AH Mk 1 pilots requiring visual correction to use SCLs is currently in place. Despite the success and general acceptance of SCLs, concerns about their performance and maintainability in an operational flight environment remain. These also will be addressed in the study questionnaire.

In addition to ocular health issues, other human factors concerns with the Apache AH Mk 1 will be addressed in the annual questionnaire. Back and neck pain are well-established complaints amongst helicopter pilots. Whilst the incidence of backache varies between aircraft, one study of British Army Air Corps pilots found that 82 percent of Gazelle helicopter pilots complained of backache (Braithwaite and Vyrnwy-Jones, 1986). The Apache AH Mk 1 benefits from newer generation, crashworthy seat design and should provide improved seat comfort over that found in older aircraft. However, the ergonomic benefits of this seat in the Apache AH Mk 1 cockpit have yet to be demonstrated and also will be addressed in this study.

Neck pain may result from poor seat position as well, but of greater concern is the increased head borne weights resulting from the use of helmet mounted systems. At 1.8 kg with the HDU attached, the IHADSS is lighter than the Mk 4 helmet most Apache AH Mk 1 pilots will have used previously (Crowley and Johnson, 1998). However, it is important to note that the maneuver capabilities of the Apache AH Mk 1 exceed those of current British army aircraft. This and the increased visual scanning required to fly while using the HMD may present an additional stress to the neck and back of Apache AH Mk 1 pilots.

Although not reviewed here, it is worth noting there are additional user concerns with the Apache AH Mk 1. Whilst they are not the primary focus of the present study, they will be addressed in the annual questionnaire to enhance the holistic care of the aviator (and for convenience sake). These concerns are: Comfort and fit of the IHADSS helmet, and cardiovascular symptoms related to low-level G, particularly the "Push-Pull Effect" (Banks et al., 1994). There are no published studies of these issues with Apache pilots although these issues have been the subject of considerable discussion in aeromedical circles.

Study design

General

A cohort of British Apache AH Mk 1 pilots (exposed group) and a control group of British Army helicopter pilots who do not fly the Apache AH Mk 1 will be followed over a 10-year period. At regular intervals, the subjects will complete questionnaires and undergo special physical examinations. The rate of change in physiological state and symptomatology will then be compared between groups, as detailed below. No payment will be made to those participating in this study.

Exposed group

All British Army pilots scheduled for conversion to the Apache AH Mk 1 will be recruited as subjects. If all eligible personnel consent to participate, it is estimated that there will be approximately 15 subjects enrolled during the first year of the study, and 40-50 enrolled every subsequent year. Although plans for manning the Apache AH Mk 1 fleet are incomplete at this time, it is reasonably certain that for the first 5 years of the program only experienced pilots will be selected for Apache AH Mk 1 training. Assuming an approximate 10 percent annual dropout rate plus a 5-year average Apache AH Mk 1 flying career (a conservative estimate), the Apache subject group will reach a steady state of approximately 190 pilots by the seventh year of the study.

Fifteen Apache rated aviators in the British Army Air Corps (AAC) have been initially identified. Of these, seven had previous AH-64A Model training and, on average, greater than 750 hours of total Apache systems flight time. Due to this high level exposure, these individuals have been restricted from the study. Of the eight remaining pilots with prior AH-64A conversion, all have been identified for entrance into the study since each pilot had approximately 40-50 hours in the AH-64A, and training had taken place greater than 2 years prior. Two of these have been excluded (one resigned his commission, the other self selected to drop out of the Apache program). A complete set of baseline data was collected on the remaining six Apache AH Mk 1 pilots, prior to the commencement of conversion training. Enrollment of subsequent Apache AH Mk 1 subjects will occur at the time of recruitment for conversion training.

Control group

All British Army pilots actively flying helicopters other than the Apache will be recruited as controls. It is estimated that approximately 200 control subjects will be enrolled by the end of the second year, and 40-50 every subsequent year.

Initial control subjects were identified during the last phase of their rotary-wing-training program. Choice was due to ease of access to the individuals as well as to the higher probability that most of these pilots will remain in the AAC for the majority of the study. Control subjects

will continue to come from this pool over the next 6 years (based on the statistical presumption that at least 5 years of data are required for each individual). Additional control subjects will be entered from the AAC regiments during the initial 6 years as well – primarily targeting younger ranks, again due to prospective retention. Baseline data will be collected in a similar fashion for the exposed population.

Since all initial examinations are off-cycle with most individual's annual aircrew medical examination, it has been determined that the initial exam will be adequate for up to 18 months in order to synchronize the study with the annual aircrew medical exam. Thereafter, data will be collected annually at the time of either group's aircrew medical examination. Those participants who are not located near a Specialist in Aviation Medicine (SAM) may only be able to contribute data at 2-year intervals. Some measures (e.g., autorefraction) may be collected off-cycle (but annually) when the necessary equipment is brought to aircrew locations on a recurring basis. Subjects will be examined at a minimum of 12 hours postexposure flight to allow for resolution of short-term effects.

It should be noted that the study is designed for cross-over (control group individuals receiving Apache transition and Apache aviators transitioning into non-Apache airframes). For example, control group members who are selected for training as Apache AH Mk 1 pilots will be recruited for the Apache exposed group, and "disenrolled" from the control group. If they consent, their most recent data as a control will be considered their baseline data as an Apache subject.

When possible, controls will be matched to subjects based on variables such as age or flight experience. As the precise number of subjects will fluctuate throughout the study, and individual contributions (i.e., length of enrollment) cannot be predicted, matching may not be possible for every analysis.

Power calculations based on a paired t-test comparing visual refractive error between the right and left eyes, with a desired power of 0.8, minimum detectable change of 0.5 diopter, and an expected standard deviation of diopter change of 1.5 diopters yields a required sample size of 73 in each group (Sigmastat version 1.0, Jandel Corporation). While the exact number of future subjects is unknown at this time, it is very likely that 73 individuals from each group will eventually join the study. This number should be also adequate for the analysis of other factors.

Ethical considerations and safety

Medical screening

Army pilots awarded an unrestricted flying medical category (A1 or A2) at annual aircrew medical examination will be deemed medically qualified to participate in this study. No further medical screening will be undertaken. Since this is a research study, enrollment must be with informed consent. Subjects will have the objectives and procedures of the study explained to

them, and they will be encouraged to ask questions. If willing to participate, they will be asked to sign a form of consent, which will be kept on file. They will be completely free to withdraw from the study at any time.

Confidentiality

All subjects will be assigned a number that will be used to identify their data. No individual will be identified by name in any ensuing publication or presentation.

Hazards

All tests performed on subjects in this study are free from discomfort or risk of injury. Similar or identical tests are part of the existing annual aircrew medical examination.

There is a small increased risk to British Army pilots of medical disqualification from flying as a consequence of this program, as several tests of visual function will be added to the annual aircrew medical examination, and others will be performed more frequently. However, aircrew medical standards are not being changed, and all these aspects will be explained in the consent form. Three of the tests proposed in this protocol for annual use (heterophoria, refractive error and stereopsis) are currently performed only during the aircrew medical examination for pilot selection. It is possible that a pilot could be medically disqualified if his/her performance was discovered to be substandard on an annual aircrew medical. However, the pilot would be treated the same if a defect was discovered, for example, during a post-accident physical examination, and every effort will be made to maintain the pilot's aircrew medical category after appropriate work-up. No aeromedical standard currently exists for three of the other four vision tests (contrast sensitivity, Lanthony D-15 color test, and eye dominance), so pilots would not be disqualified for poor performance on these tests. The remaining test, high contrast visual acuity, is already tested on the annual aircrew medical examination and poses no additional risk to the subject.

Precautions

No specific precautions are necessary as there are no significant hazards or risks to the subjects. Trained medical professionals who have been specifically briefed as to the study methods and objectives will do all testing.

Limits

If the subject requests, or if the medical or scientific supervisors determine it necessary, the subject's participation in the study will be terminated. All data obtained prior to "disenrollment" will be eligible for inclusion in the analysis. Other reasons for termination are: 1) subject ceases to fly helicopters for a period longer than 2 years, or 2) subject leaves military service.

Medical responsibility

A supervising medical officer will provide medical oversight during the study. As there are no safety or medical risks to the subjects, no formal medical monitor is necessary. The supervising medical officer will be one of the following: CA Avn Med, HQ DAAvn or U.S. Army Consultant Aerospace Medicine, HQ DAAvn.

Materials and methods

The study contains a number of annual optometric examinations and anthropometric measurements (objective measures) as well as a series of questionnaires (subjective and self-reported measures) that are administered to both groups. A summary of all test measures is provided in Table 2.

Visual measures

All tests of visual performance will be conducted monocularly and binocularly in all cases except where impractical (e.g., in eye dominance testing). Visual acuity and contrast sensitivity will be measured with and without correction (spectacles or contact lenses) if used.

Table 2.
Summary of measures taken.

Test	Dependent measure	Units
Visual acuity	Log of minimal angle resolved (logMAR); smallest readable letter	Arc seconds
Refractive error	Spherical and cylindrical power	Diopters
Contrast sensitivity	Lowest contrast letters readable	Log CS
Colour vision	Selected sequence of colour tabs	Dimensionless calculated score
Eye dominance	Eye determined to be 'sighting'	None
Maddox rod	Horizontal and vertical phorias	Prism diopters
Stereo circles	Smallest detectable disparity	Arc seconds
Nearpoint of accommodation	Shortest distance to read fine print	Millimeters
Head and neck measures	Maximal head circumference (once) and annual neck circumference	Centimeters
Questionnaire	Various	NA

Static visual acuity

High-contrast static visual acuity and low-contrast static visual acuity will be measured using Bailey-Lovie charts (Figure 3), which allow the expression of acuity as the logarithm of the

minimal angle resolved (log MAR) and the scoring of acuity as a more continuous variable than conventional Snellen charts (Bailey and Lovie, 1976). These tests consist of 14 gradually smaller rows of five letters each.

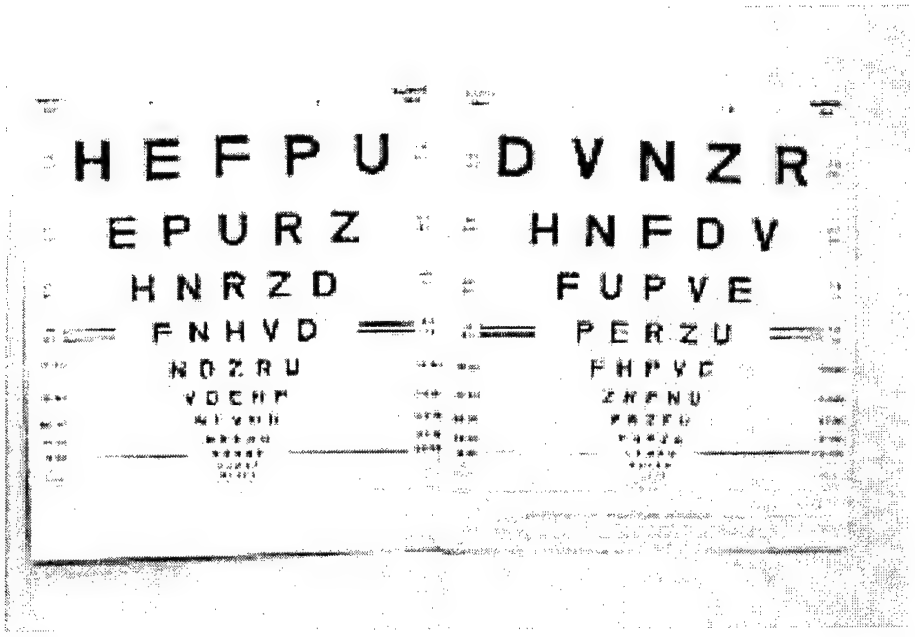

Figure 3. Bailey-Lovie charts.

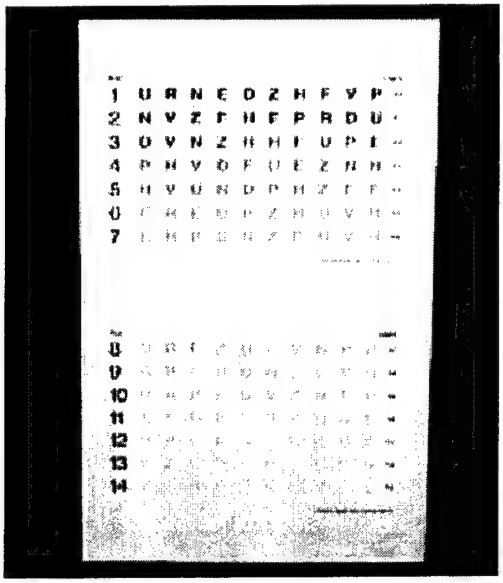

Figure 4. Contrast sensitivity chart.

Contrast sensitivity

A new chart (Figure 4) that presents different letters with decreasing levels of contrast will be used as a measure of small letter contrast sensitivity. This method has been shown to be

sensitive to small changes in visual performance. The test was developed by USAARL (Rabin and Wicks, 1996).

Color vision

The Lanthony desaturated D-15 hue test (Figure 5), adapted from the Farnsworth panel D-15 will be used (Behar et al., 1990). This test consists of 16 color chips/tabs selected from the Munsell book of color that are desaturated and appear pale and light. The subject's task is to arrange the color chips in order according to color. In order to compare small differences in performance, a modified Farnsworth FM-100 test quantitative scoring scheme will be used. An error score is calculated from the selected sequence of color tabs. Any change in color vision will trigger qualitative scoring to aid diagnosis.

Eye dominance

A test of sighting dominance will be used, as this has been shown to correlate well with other dominance measures (Behar et al., 1990). The test is called the "hole" test, in which the subject views the examiner's head through a hole in a card, then closes each eye alternately to determine which eye was used for sighting. The test will be repeated four times.

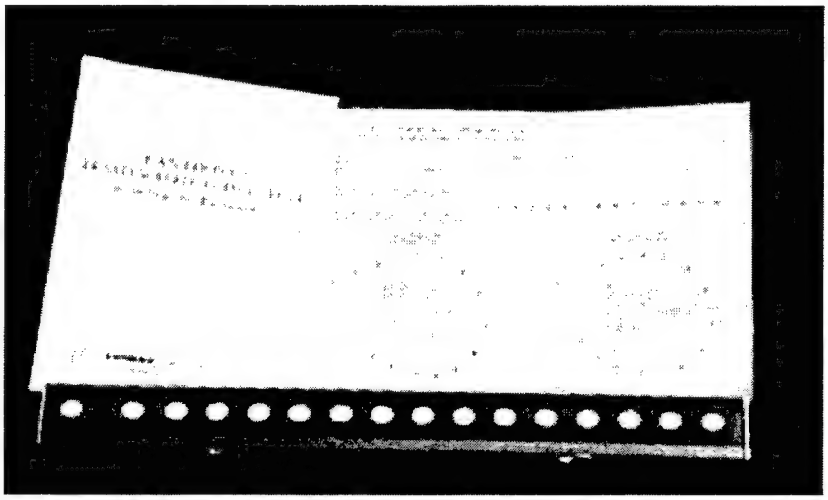

Figure 5. The Lanthony desaturated D-15 hue test.

Eye muscle balance

The Maddox rod test (Figure 6) will be used to quantify any heterophoria (Crowley et al., 1993). A Maddox rod consists of a series of thin red cylinders placed side by side, usually mounted in a circular holder that can be held before the eye. When a target light is seen through the Maddox rod, its image is a red focal line perpendicular to the axes of the cylinders. Thus, one eye sees the light source directly, while the other eye views its image through the Maddox rod. In orthophoria, the red line appears to run through the light. When the Maddox rod is held so that the cylinders are horizontal, a vertical red line is seen, which in cases of horizontal

deviation is displaced laterally. A built-in adjustable prism can be rotated until the red line appears to run through the light. The instrument is marked to indicate the angle of deviation. By rotating the Maddox rod 90 degrees, a horizontal line is produced (cylinders of the rod are vertical). Its displacement can also be measured by prisms as described above for horizontal deviations.

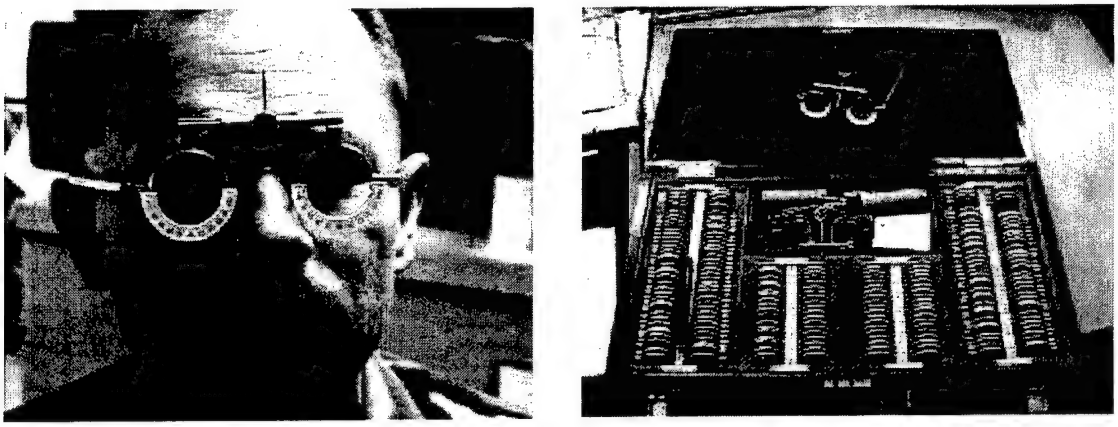

Figure 6. The Maddox rod test.

Stereopsis

Stereo vision will be measured using the Stereotest-Circles test (Stereo Optical Co., Inc., Figure 7) (Crowley et al., 1993). Subjects view arrangements of three circles through polarized spectacles and determine which circle in each group of three appears closer than the others. The task becomes progressively more difficult with each successive arrangement.

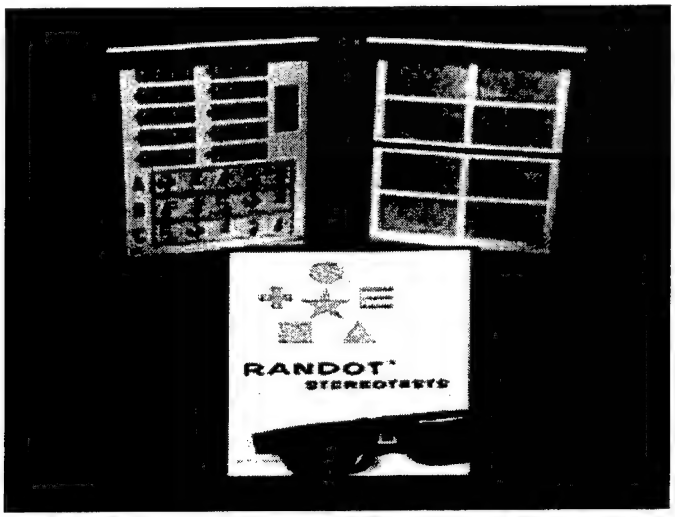

Figure 7. The Stereotest-Circles test.

Accommodative function

In the normal aircrew medical examination, this ability is measured in a binocular fashion, stimulating convergence and accommodation together by maintaining focus and fusion on a target. In this study, accommodation will also be tested monocularly by moving a small print target slowly away from each eye in turn, noting when the subject can read the letters on the target (Crowley et al., 1993). The Prince Rule will be used (Figure 8).

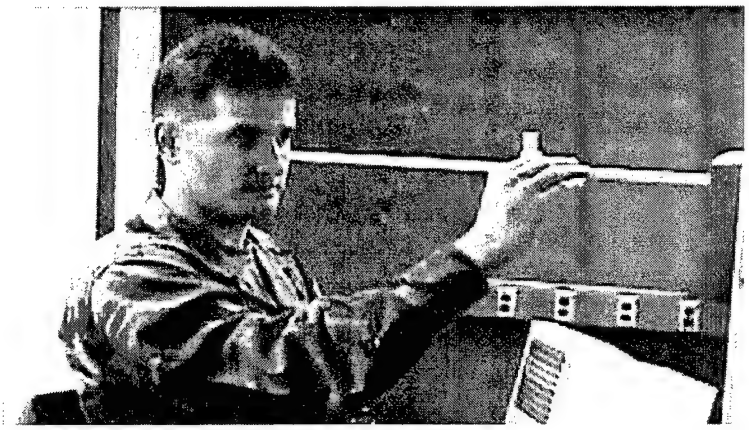

Figure 8. The Prince Rule.

Refractive error

Each subject's refractive error will be measured monocularly using an automatic refractor device (Figures 9 and 10). A reading will be taken for each eye. A single autorefractor will be used for all subjects for consistency.

Figure 9. Autorefractor.

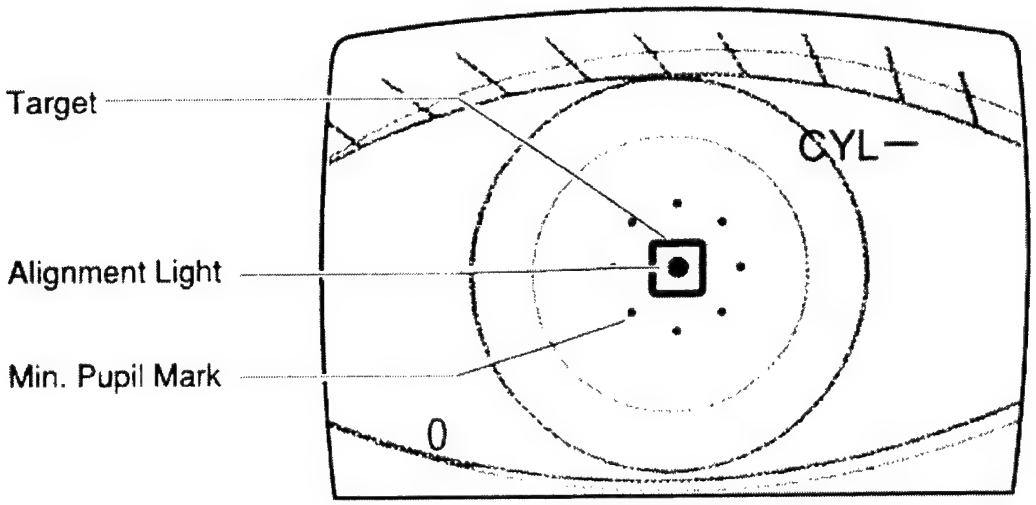

Figure 10. Artist's rendition of autorefractor targeting system.

Anthropometric measures

Each subject's maximal head circumference, neck circumference, and neck base circumference will be recorded upon entrance into the study. An annual neck circumference and neck base circumference will be completed thereafter. Neck circumference will be taken at the level of the infrathyroid landmark (Adam's apple) with the subject standing erect and the shoulders relaxed. Neck base circumference will be measured by a tape passing over the lateral and anterior neck landmarks with the subject standing erect and the shoulders relaxed (Gordon et al., 1989).

Subjective measures

Questionnaires

Upon entry to the study, each subject will complete a Subject Consent Form, a Demographic Questionnaire (Appendix A), and either an annual questionnaire for non-Apache pilots (Appendix B), or for Apache pilots (Appendix C). Both Appendices B and C are questionnaires containing about various aspects of vision and general aircrew health. For those individuals wearing contact lens, an additional questionnaire is also provided (Appendix D). Finally, all subjects will complete the Edinburgh Handedness Inventory (Oldfield, 1971), a 10-item measure of laterality (Appendix E).

Data management

Data management over the life of a 10-year project will be one of the most difficult and most time consuming aspects of the study. As the data collected for the study are medical in nature

and include biographical data, they shall be treated as any other medical record with regards to confidentiality. A secure long-term storage system for paper and electronic copies of the data is essential.

Initial data collection is via paper copy. This is then entered into a Microsoft Access® database, the Phase I database (Figure 11) by the health care provider. The paper database poses logistical and financial burdens on the project, but is considered the best alternative until an electronic data entry model is available for use by the aircrew subjects. The ideal system is a secure, web-based form for direct data entry by the subjects. This will be instituted in the Phase II Database. Access to the site will be restricted by password, and individual input to the site limited to once per survey cycle. The Phase II database is currently under development.

Once the Phase I database has been entered, the option to proceed to the separate data entry screens is provided (Figure 12). These separate data entry screens are for the subject eye exam, Annex B - biographic data, Annex C (non-WAH-64 pilots) or Annex D (WAH-64 pilots), Annex E - handedness inventory, and Appendix 1 - contact (lens) users questionnaire. Annexes C and D are entry screens for the vision/disorientation, neck pain, back pain, and helmet usage questionnaire data.

Statistical design

There will be two general statistical strategies. First, a comparison of any change in visual performance (compared to baseline) will be made between the Apache AH Mk 1 pilots and the controls (other pilots). For example, the change in accommodative function over time will be compared between groups. Second, a comparison of visual performance between the right eye (which is exposed to the HMD) and the left eye (which is not) will be made. (In essence the, left eye is acting as a control for the right.) These strategies will include comparisons of rates of change for visual parameters. These rates of change will be calculated in two ways: First, based on elapsed time (e.g., logMAR/year of change in visual acuity) and second, based on aircraft exposure (e.g., diopters/100 flight hours).

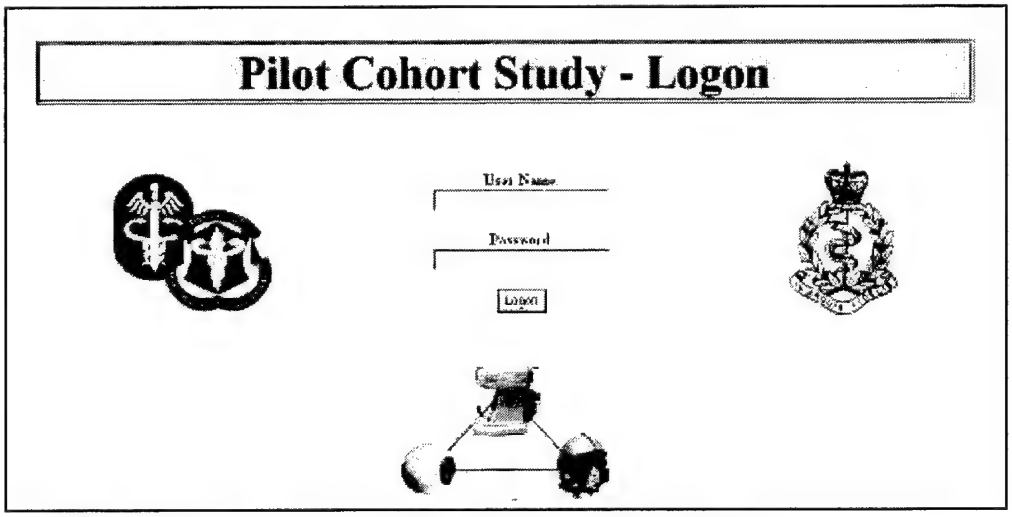

Figure 11. Phase I database logon screen.

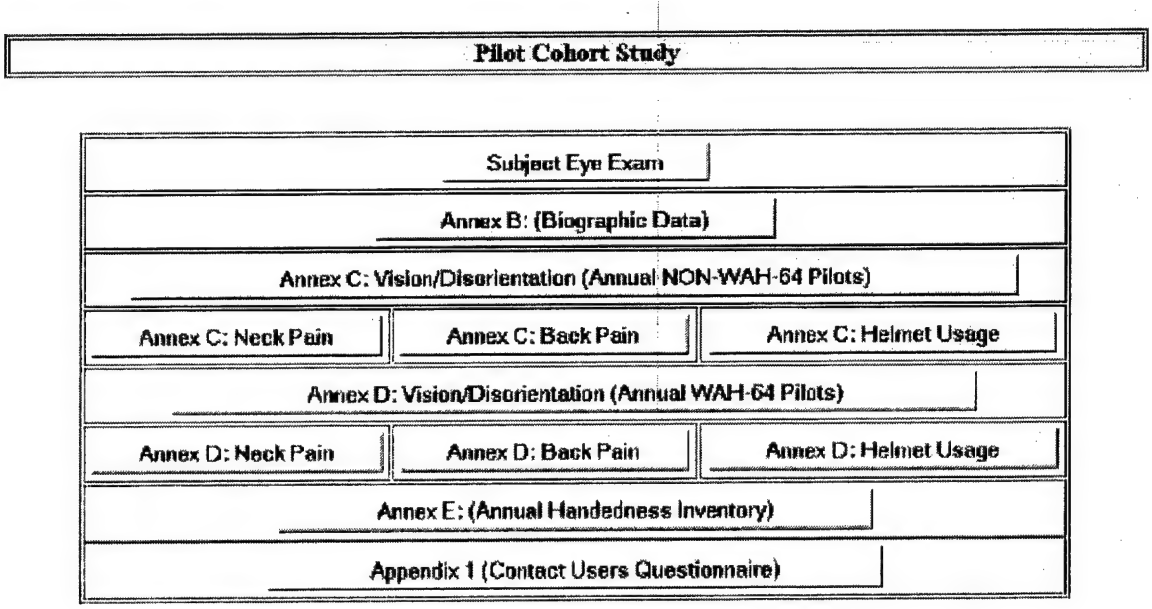

Figure 12. Phase I database entry screens.

Cost and timeline

Cost

Study costs consist of those associated with initial capital expenditure for testing equipment and with manpower.

Capital Expenditure

The USAARL has provided the study with five testing kits, which include the various optical examination testing devices (Bailey-Lovie charts, Lanthony de-saturated D-15 hue tests, contrast sensitivity charts, etc.) along with one autorefractor at an estimated cost of approximately $16,000. The Drummond Trust Foundation provides a generous annual £1,000 (~$1,460) stipend for computer system upgrades and travel expenses for the Exchange Officer on visits to the outlying Regiments. The Army Air Corps provides appropriate office space, clerical support, and photocopying facilities in support of the study.

Man-hours

A trial of the questionnaire was conducted with the aid of two experienced Standardization Pilots. The consensus was that the initial administration of the questionnaire portion of the survey should take approximately 45 - 60 minutes. The review pointed to several questions that required updating, and emphasized a need to review the questions for currency on an annual basis (e.g., terminology, equipment, training requirements and aircraft in the fleet will change over time).

The primary cost of this study can be measured in man-hours. Trial runs of the questionnaire (Annexes A, B and D) confirmed that it required approximately 45 - 60 minutes for each of the subjects to complete. Annual iterations should be considerably shorter due to familiarity with the questionnaire and the fact that Annexes A and B need only be completed upon initial enrollment into the study. A reasonable estimate for subsequent administrations of the questionnaire portion of the study is 30 - 45 minutes.

The additional survey questionnaire regarding soft contact lens wear (Appendix D) should add no more than 15 to 20 minutes to the questionnaire portion and has the potential to yield valuable information as the study progresses.

The visual systems exam portion of the study is very detailed. Fortunately, none of the individual components of the exam are particularly time consuming. During training sessions in September 1999, it was estimated that it would take approximately 15 to 20 minutes to complete the required procedures on each individual. Practical experience has shown that the exam actually approximates 30 minutes in duration.

This places the annual man-hour burden (subject) of the study at 60 - 120 minutes per subject.

The second largest source of man-hours will be the activities of the U.S. Army Exchange Officer. He will perform the bulk of the initial examinations. Eventually, the annual exams will be undertaken by the SAM of each of the Regiments on an annual basis, once the study is fully populated. All data will be forwarded to the Exchange Officer for data management. While initially a considerable amount of time will be required for the management of the database, once the Phase II database is implemented, management time requirements will decrease.

Timeline

The study has been delayed in its execution due to a number of factors. The primary factors were delays in both the initial military airworthiness release of the airframe and of the Full Mission Simulator, which directly affected the training program. The current phased execution of the study is provided in Table 3.

Table 3.
Study timeline.

PHASE:	DATES:	OBJECTIVE:	EXECUTION:
ONE	1998-00	Protocol development Ethical approval	Achieved
TWO	2000-01	Initial report submission Phase I database fielding	Achieved
THREE	2001-10	Enrollment of exposed /unexposed subjects Phase II database fielding	In progress
FOUR	2002-10	Biennial interim reports	Pending
FIVE	2010	Final report	Pending

Initial results and future directions

The protocol received ethical clearance through the U.K. Defence Medical Services Ethics Committee in 2000. The Headquarters Director of Army Aviation and the Headquarters of the Joint Helicopter Command both approved the study in 2000. The protocol also was approved by the USAARL Scientific Review and Human Use committees in 2000.

As of the date of publication of this initial report, six exposed (Apache) personnel and 50 control group personnel have been entered. The initial database has been developed. By the end of calendar year 2001, at least 100 individuals will have been entered into the study.

During 2002-2005, an additional 250-300 controls and at least 75 exposed subjects are expected to be enrolled. By this time, Phase II of the database (self entry of questionnaires) will have been fielded.

On a two-year schedule, subsequent interim technical reports will be published, culminating in the final technical report in 2010.

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Appendix A

DEMOGRAPHICS QUESTIONNAIRE:

Date questionnaire completed: _____(YYMMDD)

Name: _____
(Surname, First Name, other initials)

Service number: _____

Date of birth: _____(YYMMDD)

Present age: _____yrs

Gender: [ ] male [ ] female

When did you join the Army?: _____

Current Unit: _____

Present employment:

Pilot QHI Other (please specify)

AIRCRAFT CURRENTLY FLOWN (CIRCLE 1 OR MORE)

Lynx Gazelle A109 Bell 212 Islander

Other (please specify)_____

AVIATION EXPERIENCE

Which year did you gain your wings? : _____

Appendix B.

NON- APACHE AH MK 1 PILOT QUESTIONNAIRE:

(some question numbers have been deliberately omitted in this questionnaire)

Date questionnaire completed: _____

Name: _____ **(if subject consents to complete)**
(Surname, First Name, other initials)

Service number: _____ **(if subject consents to complete)**

Current Unit: _____

1. Present employment: Tick one only

Line Pilot [ ]
QHI [ ]
Other (please specify) [ ]_____

5b. Aircraft currently flown (circle 1 or more)

Lynx Gazelle A109 Bell 212 Islander

Other (please specify)_____

FLYING HOURS

6a. Total flight hours (rounded to nearest 10): _____

6b. Total flight hours in last year (rounded to nearest 10): _____

6c. Total flight hours in last 8 weeks (exact): _____

8a. Are you NVG current? (Tick one only)

Yes [ ]
No [ ]

8b. If yes, what category? (Circle one only) 1 2 3

9. Please give approximate number of NVG hours

9a. Total NVG hours _____

9b. In the last year: _____

9c. In last 8 weeks _____

VISION HISTORY

10a. Have you ever been prescribed spectacles? (Tick one only)

YES [ ]
NO [ ]

10b. If yes, please give reason for spectacles (For example, for distance, for reading/close work, all the time, flying only):

_____

_____

10c. Age when spectacles were first prescribed: _____

10d. Date of most recent prescription: _____

11. Have you ever worn contact lenses? (Tick one only)

Never [ ]
Discontinued wear [ ]
Presently wear [ ]

If discontinued contact lenses within last year or presently using, please fill out the supplemental form (Appendix C) for contact lens users.

12a. Do you use the **corrective flying spectacles (CFS)** with NVGs? (Tick one only)

YES [ ]
NO [ ]

12b. If yes, do the CFS interfere with your ability to use the NVG?

YES [ ]
NO [ ]

12c. If yes, please explain:

_____

13. If you do require spectacles for flying, but do **NOT** use the CSF or contact lenses, do you experience any difficulty:

a. When viewing cockpit instruments?

YES [ ]
NO [ ]

b. If yes, please explain:

_____

_____

c. When viewing outside the cockpit?

YES [ ]
NO [ ]

c. If yes, please explain:

_____

_____

14a. Have you ever been treated for an eye disease or an eye injury?

YES [ ]
NO [ ]

14b. If yes, please state when, for what reason, and do you have any continuing problems?

_____

_____

15. Do you get headaches from extended periods of close work (For example, reading small print)?

YES [ ]
NO [ ]

16. Do you ever experience eye-strain?

YES [ ]
NO [ ]

17. Which is your preferred sighting eye? (Tick one only)

Left	[ ]
Right	[ ]
Equal	[ ]
Don't know	[ ]

18. Which eye would you use with a telescope?

Left	[ ]
Right	[ ]
Equal	[ ]

19. Which eye would you use to see through a keyhole?

Left	[ ]
Right	[ ]
Equal	[ ]

21. **While flying**, have you experienced (tick one box on each row **only**):

If other than never, please comment on how often, duration of symptoms, severity of symptoms and impact on that flight.

a. Visual discomfort: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

b. Headache: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

c. Double vision: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

d. Blurred vision: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

e. After Images: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

f. Disorientation: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

g. Dizziness: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

h. Nausea: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

22. **After flying**, have you experienced (tick one box on each row **only**):

If other than never, please comment on how often, how long post flight before symptoms began, duration of symptoms, and severity of symptoms:

a. Visual discomfort: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

b. Headache: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

c. Double vision: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

d. Blurred vision: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

e. After Images: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

f. Disorientation: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

g. Dizziness: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

h. Nausea: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

i. Unsteadiness or trouble with balance:
Never [ ] Sometimes [ ] Always [ ]

25a. To what extent does flying using NVG cause eye fatigue?

Not at all [ ]
To a slight extent [ ]
To a moderate extent [ ]
To a great extent [ ]

26. How do you use your visor? (not the Face Protective Visor) (tick one on each row ONLY)

a. Day: UP [ ] DOWN [ ]

b. Night: UP [ ] DOWN [ ]

26a. If either answer is "UP", please explain why.

_____

_____

29a. **After** using the NVG, do you experience a difference in the appearance of colours?

YES [ ]
NO [ ]

29b. If 'YES', please describe what seems different:

_____

_____

29c. If 'YES', how long does this effect last? (tick one only)

<15 minutes post flight	[ ]
15 – 60 minutes post flight	[ ]
1 – 2 hours post flight	[ ]
2 – 4 hours post flight	[ ]
greater than 4 hours post flight	[ ]

30a. Have you ever experience symptoms of faintness, greying or loss of vision of any kind during periods of "aggressive" flying?

YES	[ ]
NO	[ ]

30b. If "YES", were you flying the aircraft at the time?

YES	[ ]
NO	[ ]

Describe the symptoms, their severity and duration, and the flight profile at the time of the incident.

_____

_____

DISORIENTATION

The definition of Spatial Disorientation (SD) used in the UK is as follows:

A failure to perceive correctly one's position, motion or attitude with respect to the earth's surface (horizontal reference) or the acceleration due to gravity (vertical reference).

It is **NOT** getting lost - that is **geographical** disorientation.

32a. Have you ever experienced any SD problems while using NVG?

YES	[ ]
NO	[ ]

32b. If yes, please explain the situation and cause. Include degree of SD with a description:

_____

_____

NECK PAIN

For the purposes of this survey, **neck pain** is pain **ABOVE (but not including) the level of the shoulder blades. THERE ARE SEPARATE QUESTIONS ON NECK PAIN DURING AND AFTER FLIGHT.**

40. Neck pain **DURING** flight

a. Have you ever experienced neck pain **during** a flight?

YES [ ]
NO [ ]

b. If you have experienced neck pain **during** flight, how long into the flight were you before the pain began? _____ minutes

c. Please indicate the **total number** of episodes of neck pain you have experienced **during** flight. (Tick one box only)

1-3 [ ]
4-10 [ ]
10+ [ ]

d. How many episodes of neck pain **during flight** have you had in the last year?___

e. In which aircraft have you experienced your **most frequent** neck pain (circle 1 or more)

Lynx Gazelle A109 Bell 212 Islander

Other (please specify) _____

f. Where is the **main site** of your neck pain? (tick one only)

Left side of the neck [ ]
Right side of the neck [ ]
Centre of the neck [ ]

g. Which of the following factors resulted in your neck pain **during** flight?

without NVGs [ ]
with NVGs [ ]
Other [ ] please specify_____

h. Indicate if any of the following factors may have influenced your neck pain **during** flight:

being a student pilot	[ ]
being a QHI	[ ]
infrequent flying duties	[ ]
recent illness/injury	[ ]
mission type	[ ] please specify

_____

41. Neck pain **AFTER** flight

a. Have you ever experienced neck pain **after** a flight?

YES	[ ]
NO	[ ]

b. If you have experienced neck pain **after** flight, how long into the flight were you before the pain began? _____ minutes

c. Please indicate the **total number** of episodes of neck pain you have experienced **after** flight. (Tick one box only)

1-3	[ ]
4-10	[ ]
10+	[ ]

d. How many episodes of neck pain **after flight** have you had in the last year?_____

e. Which of the following factors resulted in your neck pain **after** flight?

without NVGs	[ ]
with NVGs	[ ]
Other	[ ] please specify_____

f. Indicate if any of the following factors may have influenced your neck pain **after** flight:

being a student pilot	[ ]
being a QHI	[ ]
infrequent flying duties	[ ]
recent illness/injury	[ ]
mission type	[ ] please specify_____

42. Indicate the severity of neck pain, for the **worst** episode of pain experience during flight and after flight.

Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT _____ **AFTER FLIGHT** _____

43. If you **COMMONLY** experience neck pain, please indicate an **average** severity of pain experienced.

Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT _____ **AFTER FLIGHT** _____

44. How long did the symptoms persist for the **worst** episode of neck pain?

during flight only	[ ]
less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
more than 4 days after flight	[ ]

45. How long do the symptoms usually persist for the **average** episode of neck pain?

during flight only	[ ]
less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
more than 4 days after flight	[ ]

46a. Have your ever sought treatment for flight related neck pain?

YES	[ ]
NO	[ ]

46b. If yes, was the treatment sought from:

Specialist in Aviation Medicine (SAM)	[ ]
Military General Practitioner (GP)	[ ]
Civilian GP	[ ]
Physiotherapist	[ ]
Osteopath	[ ]
Chiropractor	[ ]
Acupuncturist	[ ]
Other (please specificy)	[ ] _____

46c. Were you given any treatment for your neck pain?

YES	[ ]
NO	[ ]

46d. If 'YES', please describe briefly the treatment you received:

_____

_____

46e. Have you ever taken any action in order to minimise or avoid flight-related neck pain?

YES	[ ]
NO	[ ]

If 'YES', please describe the type of action taken and if the action taken was effective:

_____

_____

47a. Have you ever been grounded as a result of flight-related neck pain?

YES	[ ]
NO	[ ]

47b. If 'YES', please indicate how long you were grounded:

< 1 week	[ ]
1-2 weeks	[ ]
3-4 weeks	[ ]
> 1 month	[ ]
currently grounded	[ ]

BACK PAIN

For the purposes of this survey, **back pain** is pain **at or BELOW the level of the shoulder blades**
THERE ARE SEPARATE QUESTIONS ON NECK PAIN DURING AND AFTER FLIGHT.

48. For which of the following reasons do you primarily adjust your seat? (tick one only)

Optimum vision	[ ]
Optimum control position	[ ]
A compromise between these	[ ]
Other reasons (please specify	[ ]_____

49. With your seat in the normal position, and sitting in your normal flying posture with the harness inertia reel locked, how easily can you reach and fully operate the critical and emergency controls and switches?

Not problem	[ ]
Slight difficulty	[ ]
Moderate difficulty	[ ]
Cannot reach	[ ]

50. Have you had a previous back injury?

YES	[ ]
NO	[ ]

If yes please give the date and brief details:

_____

_____

51. Back pain **DURING** flight

a. Have you ever experienced back pain **during** a flight?

YES	[ ]
NO	[ ]

b. If you have experienced back pain **during** flight, how long into the flight were you before the pain began? _____ minutes

c. Please indicate the total number of episodes of back pain you have experienced during flight:

[ ] 1-3
[ ] 4-10
[ ] +10

d. How many episodes of back pain **during flight** have you had in the last year?

_____

e. In which aircraft have you experienced your **most frequent** back pain (circle 1 or more)

Lynx Gazelle A109 Bell 212 Islander

Other (please specify) _____

f. Where is the **main site** of your back pain? (tick one only)

Lower back	[ ]
Mid back	[ ]
Shoulders	[ ]
Other (please specify)	[ ]

g. Indicate if any of the following factors may have influenced your back pain **during** flight:

unsatisfactory seat position [ ] (please explain below)

_____

length of flight	[ ] (how long before pain began?_____minutes)
infrequent flying duties	[ ]
recent illness/injury	[ ]
mission type	[ ] (please explain below)

_____

_____

52. Back pain **AFTER** flight

a. Have you ever experienced back pain **after** a flight?

YES	[ ]
NO	[ ]

b Please indicate the total number of episodes of back pain you have experienced **after** flight:

[ ] 1-3
[ ] 4-10
[ ] +10

c. How many episodes of back pain **after flight** have you had in the last year?

_____

d. Indicate if any of the following factors may have influenced your back pain **during** flight:

unsatisfactory seat position [ ] (please explain below)

_____

_____

length of flight [ ] (how long before pain began?_____minutes)
infrequent flying duties [ ]
recent illness/injury [ ]
mission type [ ] (please explain below)

_____

_____

53. Indicate the severity of back pain, for the **worst** episode of pain experience during flight and after flight.

Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT _____ **AFTER FLIGHT** _____

54. If you **COMMONLY** experience back pain, please indicate an **average** severity of pain experienced.

Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT _____ **AFTER FLIGHT** _____

55. How long did the symptoms persist for the **worst** episode of back pain?

during flight only	[ ]
less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
more than 4 days after flight	[ ]

56. How long do the symptoms usually persist for the **average** episode of back pain?

during flight only	[ ]
less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
more than 4 days after flight	[ ]

57a. Have your ever sought treatment for flight related back pain?

YES	[ ]
NO	[ ]

57b. If yes, was the treatment sought from:

Specialist in Aviation Medicine (SAM)	[ ]	
Military General Practitioner (GP)	[ ]	
Civilian GP	[ ]	
Physiotherapist	[ ]	
Osteopath	[ ]	
Chiropractor	[ ]	
Acupuncturist	[ ]	
Other (please specificy)	[ ]	_____

57c. Were you given any treatment for your back pain?

YES	[ ]
NO	[ ]

57d. If 'YES', please describe briefly the treatment you received:

_____

_____

57e. Have you ever taken any action in order to minimise or avoid flight-related back pain?

YES	[ ]
NO	[ ]

57f. If 'YES', please describe the type of action taken and if the action taken was effective:

_____

_____

58a. Have you ever been grounded as a result of flight-related back pain?

YES	[ ]
NO	[ ]

58b. If 'YES', please indicate how long you were grounded:

< 1 week	[ ]
1-2 weeks	[ ]
3-4 weeks	[ ]
> 1 month	[ ]
currently grounded	[ ]

59a. Do the standard procedures for adjusting the seat allow you to achieve a good flying position?

YES	[ ]
NO	[ ]

59b. If "NO", explain any difficulties you have with the seat adjustment mechanism. Include any additional methods you use to improve your flying position:

_____

_____

60a. How would you rate the **overall comfort** of the seat on a scale of 1 to 9.

_____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable

60b. If there is any discomfort, what causes it?

_____

_____

HELMET USAGE

61. What Mk 4 helmet size do you wear? (tick one only)

SMALL	[ ]
MEDIUM	[ ]
MEDIUM LONG	[ ]
MEDIUM BROAD	[ ]
LARGE	[ ]

62a. Grade the quality current fit on a scale of 1 to 9. _____

1 = unsatisfactory 5 = adequate 9 = excellent

62b. If less than perfectly satisfied, please describe any problem the fit causes.

_____

_____

63a. Has your helmet been adjusted by anyone other than the Safety Equipment Section fitters?

YES	[ ]
NO	[ ]

63b. If YES, by whom?

SAM	[ ]	
Self	[ ]	
QHI	[ ]	
Fellow pilot	[ ]	
Manufacturer's representative	[ ]	
Other	[ ]	please specify: _____

65. Have you experienced any breakage, binding, slipping, or other malfunction with any of the following? (circle one in each row)

Visors	No	Yes
Visor activators	No	Yes
Chinstrap	No	Yes
Suspension assembly	No	Yes
Microphone	No	Yes
Microphone Boom	No	Yes
Earcups	No	Yes
Helmet internal speakers	No	Yes

HDU mounting bracket	No	Yes
Communication cable	No	Yes
Electronics cable	No	Yes

Remarks:

_____

_____

68a. Have the NVG ever inadvertently released during flight?

YES [ ]
NO [ ]

68b. If yes, how many times has this happened? _____

69a. Do you currently achieve a full field of view with the NVG?

YES [ ]
NO [ ]

69b. If NO, assess which items of information you are not seeing:_____

71. Does the visor come down far enough? (not Face Protective Visor)

YES [ ]
NO [ ]

Remarks:

_____

_____

73. Does the visor rub your nose or face when extended?

YES [ ]
NO [ ]

Remarks:

_____

_____

74. Is the visor easily scratched?

YES [ ]
NO [ ]

Remarks:

_____

_____

75. How would you rate the **THERMAL comfort** of the helmet on a scale of 1 to 9

_____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable

If there is any discomfort, what causes it?

_____

_____

76. How would you rate the **overall comfort** of the helmet on a scale of 1 to 9

_____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable

If there is any discomfort, what causes it?

_____

_____

77. Do you feel that you currently need a different size helmet? (TICK ONE ONLY)

NO CHANGE	[ ]
SMALLER	[ ]
LARGER	[ ]

78. How would you rate the **STABILITY** of the helmet on a scale of 1 to 9 _____

1 = extremely unstable 5 = adequate 9 = extremely stable

If there is any instability, what causes it?

_____

80. How would you rate the overall **noise protection** that you have experienced in flight on a scale of 1 to 9 _____

1 = extremely noisy 5 = adequate 9 = extremely quiet

81. How would you rate the overall **quality of radio and intercom audio** that you have experienced in flight on a scale of 1 to 9 _____

1 = extremely poor 5 = adequate 9 = extremely good

82. Are the capabilities of your current helmet sufficient to allow you to safely meet all mission requirements?

YES [ ]
NO [ ]

If you would like to make additional comments, which have not been fully addressed by this survey, please do so below.

THANK YOU

Appendix C.

APACHE AH MK 1 PILOT QUESTIONNAIRE:

Date questionnaire completed: _____

Name: _____ **(if subject consents to complete)**
(Surname, First Name, other initials)

Service number: _____ **(if subject consents to complete)**

Current Unit: _____

1. Present employment: Tick one only

Converting onto AH MK 1	[ ]
Line Pilot	[ ]
QHI	[ ]
Other (please specify)	[ ]_____

2. Month and Year in which you were AH MK 1 qualified: _____

3a. In which crew position do you fly? Tick one only

Front seat	[ ]
Rear seat	[ ]
Both	[ ]

3b. If both, please estimate the percent of time you fly in each seat: Front _____ Rear _____

4. Primary aircraft prior to AH MK 1: _____

5a. Do you **currently** fly aircraft **other** than AH MK 1?

Yes	[ ]
No	[ ]

5b. If yes, please specify (Circle one or more)

Lynx Gazelle A109 Bell 212 Islander

Other (please specify)_____

FLYING HOURS

6a. Total flight hours (rounded to nearest 10): _____

6b. Total flight hours in last year (rounded to nearest 10): _____

6c. Total flight hours in last 8 weeks (exact): _____

AH MK 1 flying hours

7a. Total AH MK 1 flying hours (rounded to nearest 10): _____

7b Total AH MK 1 flying hours in last year (rounded to nearest 10):_____

7c. Total AH MK 1 flying hours in last 8 weeks (exact): _____

7d. Total AH MK 1 flying hours in last year using IHADSS (exact): _____

7e. Total AH MK 1 **simulator** hours in last year (rounded to nearest 10):_____
(include both FMS and FDS)

8a. Are you NVG current? (Tick one only)

Yes [ ]
No [ ]

8b. If yes, what category? (Circle one only) 1 2 3

9. Please give approximate number of NVG hours

9a. Total NVG hours _____

9b. In the last year: _____

9c. In last 8 weeks _____

VISION HISTORY

10a. Have you ever been prescribed spectacles? (Tick one only)

YES [ ]
NO [ ]

10b. If yes, please give reason for spectacles (For example, for distance, for reading/close work, all the time, flying only):

_____

_____

10c. Age when spectacles were first prescribed: _____

10d. Date of most recent prescription: _____

11. Have you ever worn contact lenses? (Tick one only)

Never	[ ]
Discontinued wear	[ ]
Presently wear	[ ]

If discontinued contact lenses within last year or presently using, please fill out the supplemental form (Appendix D) for contact lens users.

12a. Do you use the modified spectacles with the HMD? (Tick one only)

YES	[ ]
NO	[ ]

12b. If yes, do the modified spectacles interfere with your ability to see the HMD symbology?

YES	[ ]
NO	[ ]

12c. If yes, please explain:_____

12d. If you use modified spectacles, do you remove the right lens?

YES	[ ]
NO	[ ]

13. If you do **require spectacles for flying, but do <u>NOT</u>** use the modified spectacles or contact lenses, do you experience any difficulty:

a. When viewing cockpit instruments?

YES	[ ]
NO	[ ]

b. If yes, please explain below.

_____

c. When viewing outside the cockpit?

YES [ ]
NO [ ]

d. If yes, please explain below:

_____

_____

14a. Have you ever been treated for an eye disease or an eye injury?

YES [ ]
NO [ ]

14b. If yes, please state when, for what reason, and do you have any continuing problems?

_____

_____

15. Do you get headaches from extended periods of close work (For example, reading small print)?

YES [ ]
NO [ ]

16. Do you ever experience eye-strain?

YES [ ]
NO [ ]

17. Which is your preferred sighting eye? (Tick one only)

Left [ ]
Right [ ]
Equal [ ]
Don't know [ ]

18. Which eye would you use with a telescope?

Left [ ]
Right [ ]
Equal [ ]

19. Which eye would you use to see through a keyhole?

Left [ ]
Right [ ]
Equal [ ]

20. Is your preferred eye the same one as prior to AH MK 1 training?

YES [ ]
NO [ ]

21. **While flying** the AH MK 1, have you experienced (tick one box on each row **only**):

If other than never, please comment on how often, duration of symptoms, severity of symptoms and impact on that flight.

a. Visual discomfort: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

b. Headache: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

c. Double vision: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

d. Blurred vision: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

e. After Images: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

f. Disorientation: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

g. Dizziness: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

h. Nausea: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

22. **After flying** the AH MK 1, have you experienced (tick one box on each row **only**):

If other than never, please comment on how often, how long post flight before symptoms began, duration of symptoms, and severity of symptoms:

a. Visual discomfort: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

b. Headache: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

c. Double vision: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

d. Blurred vision: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

e. After Images: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

f. Disorientation: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

g. Dizziness: Never [ ] Sometimes [ ] Always [ ]
comment:_____

_____

h. Nausea: Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

i. Unsteadiness or trouble with balance:
Never [ ] Sometimes [ ] Always [ ]

comment:_____

_____

23a. Have you noted any change in your ability to see or interpret the HMD symbology during any phase of flight?

YES [ ]
NO [ ]

23b. If yes, please explain:

_____

24. When viewing through the HMD, do you have difficulty focussing clearly on the external scene and symbology simultaneously?

Grade how frequently this affects you on a scale of 1 to 9. _____

1 = never 5 = 50% of the time 9 = always.

25. To what extent does flying by reference to the HDU cause eye fatigue?

a. At Night using PNVS/TADS (tick one box only)

Not at all [ ]
To a slight extent [ ]
To a moderate extent [ ]
To a great extent [ ]

b. During daytime flight using PNVS/TADS (tick one box only)

Not at all [ ]
To a slight extent [ ]
To a moderate extent [ ]
To a great extent [ ]

26. How do you use your visor? (tick one on each row ONLY)

a. Day: UP [ ] DOWN [ ]

b. Night: UP [ ] DOWN [ ]

26a. If either answer is "UP", please explain why.

_____

_____

27. **During** AH MK 1 flight, does your vision sometimes unintentionally alternate between two eyes?

Grade how frequently this affects you on a scale of 1 to 9. _____

1 = never 5 = 50% of the time 9 = always.

If other than never, please explain and estimate the duration.

_____

_____

28. **After** AH MK 1 flight, does your vision sometimes unintentionally alternate between two eyes?
Grade how frequently this affects you on a scale of 1 to 9. _____

1 = never 5 = 50% of the time 9 = always.

If other than never, please explain and estimate the duration.

_____

29a. **After** using the IHADSS, do you experience a difference in the appearance of colours?

YES [ ]
NO [ ]

29b. If 'YES', please describe what seems different:

_____

29c. If 'YES', how long does this effect last? (tick one only)

<15 minutes post flight	[ ]
15 – 60 minutes post flight	[ ]
1 – 2 hours post flight	[ ]
2 – 4 hours post flight	[ ]
greater than 4 hours post flight	[ ]

30a. Have you ever experience symptoms of faintness, greying or loss of vision of any kind during periods of "aggressive" flying?

YES	[ ]
NO	[ ]

30b. If "YES", were you flying the aircraft at the time?

YES	[ ]
NO	[ ]

Describe the symptoms, their severity and duration, and the flight profile at the time of the incident.

_____

_____

DISORIENTATION

The definition of Spatial Disorientation (SD) used in the UK is as follows:

A failure to perceive correctly one's position, motion or attitude with respect to the earth's surface (horizontal reference) or the acceleration due to gravity (vertical reference).

It is **NOT** getting lost - that is **geographical** disorientation.

31a. **During your conversion onto AH MK 1**, did you ever experienced any SD problems while using the HDU?

YES	[ ]
NO	[ ]

31b. If yes, please explain the situation and cause. Include degree of SD with a description:

_____

_____

32a. **As a line pilot**, have you ever experienced any SD problems while using the HDU? (please exclude SD during the conversion course)

YES	[ ]
NO	[ ]

32b. If yes, please explain the situation and cause. Include degree of SD with a description:

_____

_____

33. When viewed through the HDU, do objects appear: (Please tick one)

Larger and closer than in reality? [ ]

Smaller and farther away than in reality? [ ]

About the right size and distance? [ ]

Any further comments:

_____

_____

34. To what extent have you experienced problems with time lags associated with the symbology that made it difficult to correlate the symbol movement with the aircraft movement, and thus required some degree of compensation to fly the aircraft? (tick one box only)

Not at all	[ ]
To a slight extent	[ ]
To a moderate extent	[ ]
To a great extent	[ ]

If other than not at all, for what symbols does this occur? Please explain:

_____

_____

35. To what extent have you experienced problems with the PNVS image lagging behind your head motion? (tick one box only)

Not at all	[ ]
To a slight extent	[ ]
To a moderate extent	[ ]
To a great extent	[ ]

Please explain:

_____

_____

36. When looking through the HDU, how frequently do you have to switch your visual attention from the terrain to the flight symbology when acquiring flight information?

Grade how frequently on a scale of 1 to 9. _____

1 = never 5 = 50% of the time 9 = always.

If other than never, please explain and estimate the duration.

_____

_____

37. During night flight operations, have you ever experienced a situation in which flashes of light occurring in the left visual field tend to "wash-out" the information being presented on the HDU to the right eye?

YES [ ]
NO [ ]

If yes, please explain:

_____

_____

38. Does the difference between sensor location (on the nose of the aircraft) and eye location create problems with obstacle clearance (to the sides of the aircraft and below the aircraft)?

YES [ ]
NO [ ]

If yes, under what conditions and manoeuvres do you most often experience this problem:

_____

_____

39. During long duration flights (over 2 hours), how often do you experience problems with the flight symbology "disappearing" from view due to fatigue?

Grade how frequently on a scale of 1 to 9. _____

1 = never 5 = 50% of the time 9 = always.

If other than never, please explain including how you compensate for this problem:

_____

_____

NECK PAIN

For the purposes of this survey, **neck pain** is pain **ABOVE (but not including) the level of the shoulder blades. THERE ARE SEPARATE QUESTIONS ON NECK PAIN DURING AND AFTER FLIGHT.**

40. Neck pain **DURING** flight

a. Have you ever experienced neck pain **during** a flight?

YES	[ ]
NO	[ ]

b. If you have experienced neck pain **during** flight, how long into the flight were you before the pain began? _____ minutes

c. Please indicate the **total number** of episodes of neck pain you have experienced **during** flight. (Tick one box only)

1-3	[ ]
4-10	[ ]
10+	[ ]

d. How many episodes of neck pain **during flight** have you had in the last year?___

e. In which aircraft have you experienced your **most frequent** neck pain (circle 1 or more)

AH MK 1 Lynx Gazelle A109 Bell 212
Islander Other (please specify) _____

f. Where is the **main site** of your neck pain? (tick one only)

Left side of the neck	[ ]
Right side of the neck	[ ]
Centre of the neck	[ ]

g. Which of the following factors resulted in your neck pain **during** flight?

without NVGs	[ ]
with NVGs	[ ]
IHADSS helmet without HDU	[ ]
IHADSS helmet with HDU	[ ]
Other	[ ] please specify_____

h. Indicate if any of the following factors may have influenced your neck pain **during** flight:

being a student pilot	[ ]
being a QHI	[ ]
infrequent flying duties	[ ]
recent illness/injury	[ ]
mission type	[ ] please specify _____

41. Neck pain **AFTER** flight

a. Have you ever experienced neck pain **after** a flight?

YES	[ ]
NO	[ ]

b. If you have experienced neck pain **after** flight, how long into the flight were you before the pain began?

_____ minutes

c. Please indicate the **total number** of episodes of neck pain you have experienced **after** flight. (Tick one box only)

1-3	[ ]
4-10	[ ]
10+	[ ]

d. How many episodes of neck pain **after flight** have you had in the last year?___

e. Which of the following factors resulted in your neck pain **after** flight?

without NVGs	[ ]
with NVGs	[ ]
IHADSS helmet without HDU	[ ]
IHADSS helmet with HDU	[ ]
Other	[ ] please specify_____

f. Indicate if any of the following factors may have influenced your neck pain **after** flight:

being a student pilot	[ ]
being a QHI	[ ]
infrequent flying duties	[ ]
recent illness/injury	[ ]
mission type	[ ] please specify _____

42. Indicate the severity of neck pain, for the **worst** episode of pain experience during flight and after flight.

Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT _____ **AFTER FLIGHT** _____

44. If you **COMMONLY** experience neck pain, please indicate an **average** severity of pain experienced.

Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT _____ **AFTER FLIGHT** _____

44. How long did the symptoms persist for the **worst** episode of neck pain?

during flight only	[ ]
less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
more than 4 days after flight	[ ]

45. How long do the symptoms usually persist for the **average** episode of neck pain?

during flight only	[ ]
less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
more than 4 days after flight	[ ]

46a. Have your ever sought treatment for flight related neck pain?

YES	[ ]
NO	[ ]

46b. If yes, was the treatment sought from:

Specialist in Aviation Medicine (SAM)	[ ]
Military General Practitioner (GP)	[ ]
Civilian GP	[ ]
Physiotherapist	[ ]
Osteopath	[ ]
Chiropractor	[ ]
Acupuncturist	[ ]
Other (please specificy)	[ ] _____

46c. Were you given any treatment for your neck pain?

YES	[ ]
NO	[ ]

46d. If 'YES', please describe briefly the treatment you received:

_____

_____

46e. Have you ever taken any action in order to minimise or avoid flight-related neck pain?

YES	[ ]
NO	[ ]

If 'YES', please describe the type of action taken and if the action taken was effective:

_____

_____

47a. Have you ever been grounded as a result of flight-related neck pain?

YES	[ ]
NO	[ ]

47b. If 'YES', please indicate how long you were grounded:

< 1 week	[ ]
1-2 weeks	[ ]
3-4 weeks	[ ]
> 1 month	[ ]
currently grounded	[ ]

BACK PAIN

For the purposes of this survey, **back pain** is pain **at or BELOW the level of the shoulder blades**
THERE ARE SEPARATE QUESTIONS ON NECK PAIN DURING AND AFTER FLIGHT.

48. For which of the following reasons do you primarily adjust your seat? (tick one only)

Optimum vision	[ ]
Optimum control position	[ ]
A compromise between these	[ ]
Other reasons (please specify	[ ]

_____

49. With your seat in the normal position, and sitting in your normal flying posture with the harness inertia reel locked, how easily can you reach and fully operate the critical and emergency controls and switches?

Not problem	[ ]
Slight difficulty	[ ]
Moderate difficulty	[ ]
Cannot reach	[ ]

50. Have you had a previous back injury?

YES	[ ]
NO	[ ]

If yes please give the date and brief details:

_____

_____

51. Back pain **DURING** flight

a. Have you ever experienced back pain **during** a flight?

YES	[ ]
NO	[ ]

b. If you have experienced back pain **during** flight, how long into the flight were you before the pain began? _____ minutes

c. Please indicate the total number of episodes of back pain you have experienced during flight:

[ ] 1-3
[ ] 4-10
[ ] +10

d. How many episodes of back pain **during flight** have you had in the last year?

---

e. In which aircraft have you experienced your **most frequent** back pain (circle 1 or more)

AH MK 1 Lynx Gazelle A109 Bell 212
Islander Other (please specify) _____

f. Where is the **main site** of your back pain? (tick one only)

Lower back [ ]
Mid back [ ]
Shoulders [ ]
Other (please specify) [ ]

g. Indicate if any of the following factors may have influenced your back pain **during** flight:

unsatisfactory seat position [ ] (please explain below)

---

length of flight [ ] (how long before pain began?_____minutes)
infrequent flying duties [ ]
recent illness/injury [ ]
mission type [ ] (please explain below)

---

52. Back pain **AFTER** flight

a. Have you ever experienced back pain **after** a flight?

YES [ ]
NO [ ]

b Please indicate the total number of episodes of back pain you have experienced **after** flight:

[ ] 1-3
[ ] 4-10
[ ] +10

c. How many episodes of back pain **after flight** have you had in the last year?

_____

d. Indicate if any of the following factors may have influenced your back pain **during** flight:

unsatisfactory seat position [ ] (please explain below)

_____

length of flight	[ ] (how long before pain began?_____minutes)
infrequent flying duties	[ ]
recent illness/injury	[ ]
mission type	[ ] (please explain below)

_____

53. Indicate the severity of back pain, for the **worst** episode of pain experience during flight and after flight.

Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT _____ **AFTER FLIGHT** _____

55. If you **COMMONLY** experience back pain, please indicate an **average** severity of pain experienced.

Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT _____ **AFTER FLIGHT** _____

55. How long did the symptoms persist for the **worst** episode of back pain?

during flight only	[ ]
less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
more than 4 days after flight	[ ]

56. How long do the symptoms usually persist for the **average** episode of back pain?

during flight only	[ ]
less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
more than 4 days after flight	[ ]

57a. Have your ever sought treatment for flight related back pain?

YES	[ ]
NO	[ ]

57b. If yes, was the treatment sought from:

Specialist in Aviation Medicine (SAM)	[ ]	
Military General Practitioner (GP)	[ ]	
Civilian GP	[ ]	
Physiotherapist	[ ]	
Osteopath	[ ]	
Chiropractor	[ ]	
Acupuncturist	[ ]	
Other (please specificy)	[ ]	_____

57c. Were you given any treatment for your back pain?

YES	[ ]
NO	[ ]

57d. If 'YES', please describe briefly the treatment you received:

_____

_____

57e. Have you ever taken any action in order to minimise or avoid flight-related back pain?

YES	[ ]
NO	[ ]

57f. If 'YES', please describe the type of action taken and if the action taken was effective:

_____

_____

58a. Have you ever been grounded as a result of flight-related back pain?

YES	[ ]
NO	[ ]

58b. If 'YES', please indicate how long you were grounded:

< 1 week	[ ]
1-2 weeks	[ ]
3-4 weeks	[ ]
> 1 month	[ ]
currently grounded	[ ]

59a. Do the standard procedures for adjusting the seat allow you to achieve a good flying position?

YES	[ ]
NO	[ ]

59b. If "NO", explain any difficulties you have with the seat adjustment mechanism. Include any additional methods you use to improve your flying position:

_____

_____

60a. How would you rate the **overall comfort** of the seat on a scale of 1 to 9.

_____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable

60b. If there is any discomfort, what causes it?

_____

_____

IHADSS HELMET USAGE

61. What helmet size do you wear? (tick one only)

MEDIUM	[ ]
LARGE	[ ]
EXTRA LARGE	[ ]

62a. Grade the quality current fit on a scale of 1 to 9. _____

1 = unsatisfactory 5 = adequate 9 = excellent

62b. If less than perfectly satisfied, please describe any problem the fit causes.

_____

_____

63a. Has your helmet been adjusted by anyone other than the Safety Equipment Section fitters?

YES	[ ]
NO	[ ]

63b. If YES, by whom?

SAM	[ ]	
Self	[ ]	
QHI	[ ]	
Fellow pilot	[ ]	
Manufacturer's representative	[ ]	
Other	[ ]	please specify: _____

64a. Has the IHADSS suspension system rigid inner liner been modified in any manner? (Example; cut, ground, shaved, etc.)

YES	[ ]
NO	[ ]

64b. If YES, please tick below: (More than one may apply.)

Front	[ ]
Back	[ ]
Top	[ ]
Bottom	[ ]
Left	[ ]
Right	[ ]

64c. If YES, by whom (no names) ?

Safety Equipment Section fitters	[ ]	
SAM	[ ]	
Self	[ ]	
QHI	[ ]	
Fellow pilot	[ ]	
Manufacturer's representative	[ ]	
Other	[ ]	please specify: _____

65. Have you experienced any breakage, binding, slipping, or other malfunction with any of the following? (circle one in each row)

Visors	No	Yes
Visor activators	No	Yes
Chinstrap	No	Yes
Suspension assembly	No	Yes
Microphone	No	Yes
Microphone Boom	No	Yes
Earcups	No	Yes
Helmet internal speakers	No	Yes
HDU mounting bracket	No	Yes
Communication cable	No	Yes
Electronics cable	No	Yes

Remarks:

_____

_____

66. Have you experienced any discomfort while using the HDU?

YES	[ ]
NO	[ ]

Remarks:

_____

_____

67. Have you experienced any difficulty installing or removing the HDU from the helmet?

YES [ ]
NO [ ]

Remarks:

_____

_____

68a. Has the HDU ever inadvertently released during flight?

YES [ ]
NO [ ]

68b. If yes, how many times has this happened? _____

69a. Do you currently achieve a full field of view?

YES [ ]
NO [ ]

69b. If NO, assess which items of information you are not seeing:_____

70. Was the custom trimming of the visor accurate and adequate?

YES [ ]
NO [ ]

Remarks:

_____

_____

71. Does the visor come down far enough?

YES [ ]
NO [ ]

Remarks:

_____

_____

72. Has the visor ever inadvertently retracted?

YES [ ]
NO [ ]

Remarks:

_____

_____

73. Does the visor rub your nose or face when extended?

YES [ ]
NO [ ]

Remarks:

_____

_____

74. Is the visor easily scratched?

YES [ ]
NO [ ]

Remarks:

_____

_____

75a. How would you rate the **THERMAL comfort** of the IHADSS helmet on a scale of 1 to 9

_____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable

75b. If there is any discomfort, what causes it?

_____

_____

76a. How would you rate the **overall comfort** of the IHADSS helmet on a scale of 1 to 9

_____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable

76b. If there is any discomfort, what causes it?

_____

_____

77. Do you feel that you currently need a different size IHADSS helmet? (TICK ONE ONLY)

NO CHANGE [ ]
SMALLER [ ]
LARGER [ ]

78a. How would you rate the **STABILITY** of the IHADSS helmet on a scale of 1 to 9

_____

1 = extremely unstable 5 = adequate 9 = extremely stable

78b. If there is any instability, what causes it?

_____

_____

79a. Have you had any problems boresighting the TADS?

YES [ ]
NO [ ]

79b. If YES, what was the problem?

_____

_____

79c. What was done to correct the problem?

_____

_____

79d. Do you have any suggestions on how to better correct this problem?

_____

_____

80. How would you rate the overall **noise protection** that you have experienced in flight on a scale of 1 to 9

_____

1 = extremely noisy 5 = adequate 9 = extremely quiet

81. How would you rate the overall **quality of radio and intercom audio** that you have experienced in flight on a scale of 1 to 9 _____

1 = extremely poor 5 = adequate 9 = extremely good

82. Are the capabilities of the IHADSS system sufficient to allow you to safely meet all mission requirements?

YES	[ ]
NO	[ ]

If you would like to make additional comments on the capabilities or limitations of the IHADSS system, which have not been fully addressed by this survey, please do so below.

THANK YOU

Appendix D.

CONTACT LENS USERS SURVEY

Date questionnaire completed: _____

Name: _____
(Surname, First Name, other initials)

Service number: _____

a. If contact lens wear was discontinued within the last year, please give the reason.
_____

_____

b. Please rate your experiences in inserting your lenses. (1-9)_____
1 = No problems what-so-ever
5 = Minor problems
9 = Severe problems

c. Please rate your experiences in removing your lenses. (1-9)_____
1 = No problems what-so-ever
5 = Minor problems
9 = Severe problems

d. In general, how comfortable are your contact lenses?(1-9)_____
1 = Very comfortable
5 = Neither comfortable nor uncomfortable
9 = Very uncomfortable

e. How do you rate your vision with contact lenses as opposed to your vision with spectacles?
(1-9)_____
1 = Much better with contact lenses
5 = No difference between contact lenses and glasses
9 = Much better with glasses

f. Have you experienced any difficulty **maintaining** your contact lenses?
At home/in barracks YES NO
In the field YES NO
If yes, please explain: _____

g. Did any of the following weather conditions make the wearing of contact lenses difficult? (Check all that apply.)

_____ Hot weather
_____ Wet weather
_____ Sunny weather
_____ Dusty conditions
_____ Cold weather
_____ Dry weather
_____ Windy weather
_____ Other(explain)

h. Since your last contact lens review, have you experienced any of the following problems **while flying**? Tick only those that apply.

FREQUENCY

	Never	Rarely	Occasionally	Often
Eye irritation				
Eye pain				
Blurred vision				
Dry eye				
Light sensitivity				

i. If any of the above occurred, how bothersome was it?

SEVERITY

	Minor	Moderate	Severe
Eye irritation			
Eye pain			
Blurred vision			
Dry eye			
Light sensitivity			

j. Since your last contact lens review, did you experience any of the following problems **while on the ground**? Tick only those that apply.

FREQUENCY

	Never	Rarely	Occasionally	Often
Eye irritation				
Eye pain				
Blurred vision				
Dry eye				
Light sensitivity				

k. If any of the above occurred, how bothersome was it?

SEVERITY

	Minor	Moderate	Severe
Eye irritation			
Eye pain			
Blurred vision			
Dry eye			
Light sensitivity			

l. If you use contact lenses during flight, how would you rate their overall comfort?
(1-9) _____
1 = unsatisfactory
5 = adequate
9 = excellent
Comments:

m. If you use contact lenses during flight, have difficulties with the lenses caused you to:
(tick all that apply)

Reschedule or cancel flights	YES	NO
Deviate from flight plan	YES	NO
Hand over control in flight	YES	NO
Remove a lens in flight	YES	NO
Use eye drops in flight	YES	NO

If yes, please explain:

_____

_____

n. If this is your first year wearing lenses, please evaluate the training that you have received in the following aspects:

	Application	Removal
Ineffective	_____	_____
Poor	_____	_____
Fair	_____	_____
Good	_____	_____
Excellent	_____	_____

o. Overall, how would you rate the Army Aviation Medicine support of the contact lens programme?
(1-9)_____
1 = Ineffective
5 = Fair
9 = Excellent

p. Finally, please comment on how the support for AH MK 1 pilots who use contact lenses could be improved:

_____

_____

_____

_____

_____

_____

_____

Appendix E.

THE EDINBURGH HANDEDNESS INVENTORY

NAME:_____(Surname, First, MI)

DATE:_____ (YYMMDD)

Please indicate your preferences in the use of hands in the following activities by putting a "+" in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put "++". If in any case you are really indifferent, put "+" in both columns.

Some of the activities require both hands. In these cases, the part of the task, or object, for which hand preference is wanted, is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all with the object or task.

TASK OR OBJECT	LEFT	RIGHT
1. Writing		
2. Drawing		
3. Throwing		
4. Scissors		
5. Toothbrush		
6. Knife (without fork)		
7. Spoon		
8. Broom (upper hand)		
9. Striking match (match hand)		
10. Opening box (lid)		
Do not write below this line		
#R:___ - #L:___ =___/ #R + #L = ___ X 100 = EHI ___		

Appendix F.

List of acronyms.

ACRONYM	DEFINITION
ACC	Army Air Corps
ANVIS	Aviator's Night Vision Imaging System
CA	Consultant Advisor
CHS	Centre for Human Sciences
CRT	cathode ray tube
DAAvn	Director of Army Aviation
DERA	Defence Evaluation and Research Agency
FOV	field of view
HDU	helmet display unit
HMD	helmet-mounted display
IHADSS	Integrated Helmet and Display Sighting System
NVG	night vision goggles
MAR	Minimum Angle Resolved
SAM	Specialist in Aviation Medicine
SCL	soft contact lens
USAARL	United States Army Aeromedical Research Laboratory
WAH	Westland attack helicopter

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